



TM-4000CL Series Progressive Scan Shutter Cameras

Operation Manual

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Warranty

All of our solid-state cameras sold in North America have a full three-year warranty. Those sold elsewhere have a full one-year warranty. If any such product proves defective during the warranty period, JAI PULNiX, Inc. will repair the defective product without charge for parts and labor or will provide a replacement in exchange for the defective product. This warranty shall not apply to any damage, defect or failure caused by improper use or inadequate maintenance.

Certifications

CE Compliance

The TM-4000CL series of cameras has been certified to conform to the requirements of Council Directive 89/336/EC for electromagnetic compatibility and to comply with the following European Standards:

Immunity: EN50082-2/1997

Emissions: CISPR22: 1997/EN55011: 1998 Class B

All PULNiX products bearing the CE mark have been declared to be in conformance with the applicable EEC Council Directives. However, certain factory-installed options or customer-requested modifications may compromise electromagnetic compatibility and affect CE compliance. Please note that the use of interconnect cables that are not properly grounded and shielded may affect CE compliance.

Contact PULNiX Applications Engineering Department for further information regarding CE compliance.

FCC

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case the user will be required to correct the interference at his own expense.

WARNING

**Changes or modifications to this unit not expressly approved by the party responsible for
FCC compliance could void the user's authority to operate the equipment.**

TM-4000CL Series Operation Manual

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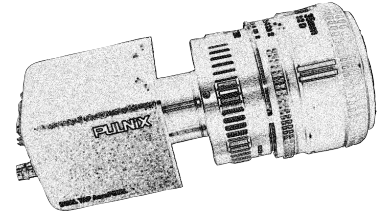
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TM-4000CL Series Progressive Scan Shutter Cameras

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1 Introduction

1.1 Product Description

The PULNiX TM-4000CL series¹ consists of dual-tap output, high-resolution, high-speed monochrome progressive scan CCD cameras. ²The interline-type CCD permits full vertical and horizontal resolution of very high speed shutter images and applications. The electronic shutter, which has speeds to 1/16,000 sec., can be reset asynchronously by external pulse control. The frame rate is 15 fps. A square imager format with uniform square pixels provides superior image definition in any orientation. On-chip micro lenses provide increased sensitivity.

The TM-4000CL has a full dynamic range control function, which can be set at externally selectable look-up table (LUT)³ knee slopes to convert 10-bit input to 8-bit output, thereby optimizing the CCD's full dynamic range in the normal output signal range. As dual-tap outputs camera, the TM-4000CL has dual-channel auto-block level balancing and auto-gain balancing functions. The camera has a dual-tap, 10-bit or 8-bit Camera Link output. All the key functions are controlled via Camera Link serial communication interface.

Multi-camera operation requires synchronized data and clock phases from each camera. The TM-4000CL has a pixel clock locking phase lock loop (PLL) for multi-camera operation that is offered as standard.

-
1. The TM-4000CL is available with either 8-bit processing or 10-bit processing. You must specify your choice of configurations when you purchase the camera.
 2. The TM-4000CL series consists of the TM-4000CL (monochrome) and the TMC-4000CL (color). Unless otherwise noted, all information contained in this manual is relevant to both models.
 3. The TM-4000CL 8-bit output camera has an LUT, which the 10-bit camera does not have.

Applications for the TM-4000CL include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high-security surveillance.

1.2 Features

- **Miniaturized and lightweight**

The printed circuit boards in the TM-4000CL have been arranged based on a new design philosophy. This creates modular electronics for the camera, giving it flexibility. In addition, the use of miniature solid-state components results in a compact, lightweight camera that is 50.8mm x 50.8mm x 81.5mm in dimensions, and weighs only 155 grams.

- **Imager**

The TM-4000CL uses a dual-tap progressive-scan interline transfer CCD that has the following features:

- Resolution of 2048 x 2048 active pixels for excellent image quality.
- 7.4 x 7.4 μm square pixels for precise dimensional measurement.
- High-speed electronic shutter capability for high dynamic resolution of moving objects and electronic iris control that eliminates the need for a mechanical shutter.
- Progressive-scan CCD eliminates interlace deterioration of image and increases ease of computer interface.
- High sensitivity and low noise at fast scanning. The CCD has an excellent S/N ratio that is greater than 48dB.
- The CCD has a built-in microlens for increased quantum efficiency.

- **Electronic shutter**

The TM-4000CL has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing. A built-in manual shutter speed control selects the electronic shutter rate of 1/60 (non-async mode only), 1/125, 1/250, 1/500, 1/1,000, 1/2,000, 1/4,000, 1/8,000, or 1/16,000 second.

With VINIT high (5V), the CCD keeps discharging. With a negative pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 2048 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

- **Asynchronous reset**

The TM-4000CL captures async reset images and provides single-shot video output with single FDV. This makes it simpler for an ordinary frame grabber to capture the async reset images. The TM-4000CL's asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied to CC1, it resets the camera's scanning and purging of the CCD.

The TM-4000CL has two modes to control the asynchronous reset and shutter speed:

- **External VINIT with pulse width.** The duration between pulse edges controls the shutter speed externally.
- **Internal shutter speed control.** The speed control varies from 1/125 to 1/16,000 sec. The video signal and FDV starts with internal V reset timing related to shutter speed.

- **Output**

The TM-4000CL has a dual tap 10-bit or 8-bit Camera Link output. The analog output is 714 mVp-p composite video (75 ohms) on all models.

- **Dual-Channel Auto Black Level Balancing and Auto Gain**

The TM-4000CL, as a dual-tap output camera, has dual-channel auto black level balancing and auto gain balancing functions.

- **Integration**

The TM-4000CL is capable of capturing high-resolution integration images. Its CCD imager can be exposed for longer than the normal scan timing of 1/15 sec. This integration feature provides extra sensitivity for applications in dark environments. The progressive scan imager permits a full frame of resolution in non-interlace format. Integration is achieved by applying INTEG signal to CC2 control of Camera Link or by feeding VINIT pulse width control up to 1 sec of the pulse width in async pulse width control mode for the frames to be integrated.

- **Three-Year Warranty**

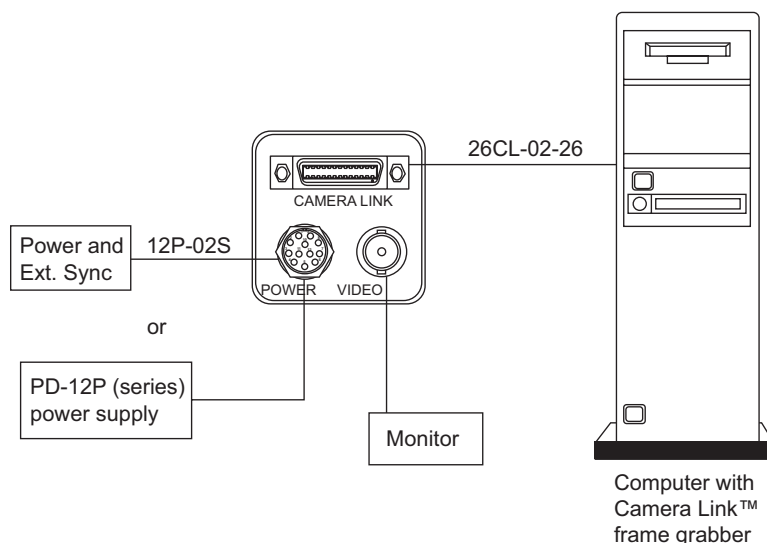
The CCD solid-state image sensor allows the camera to maintain a superior performance level indefinitely while requiring virtually no maintenance. PULNiX backs all of the TM-series cameras with a three-year warranty.

Warning: Unscrewing the camera cover or opening the camera in any way will void this warranty unless prior written approval is obtained from the factory.

1.3 System Configuration

FIGURE 1. CL (Camera Link) System Configuration

Figure 1 below presents a typical system configuration for the Camera Link version.



2 Installation

The following instructions are provided to help you to set up your camera quickly and easily. We suggest that you read through these instructions before you unpack and set up your camera system.

2.1 Getting Started

2.1.1 Unpacking Instructions

We recommend that you save the original packing cartons for the cameras and accessories in case you need to return or exchange an item.

We also recommend that you bench-test any equipment being sent to another location for field installation to assure that everything is fully operational as a system.

2.1.2 Components List

Please begin by checking your order against the Components List shown below to assure that you have received everything as ordered, and that nothing has been overlooked in the packing materials. If any item is missing, please contact your PULNiX representative immediately.

- TM-4000CL camera
- Camera-specific data sheet
- Camera-appropriate operation manual (if ordered)
- Dual-tap AccuPiXEL camera-control software

2.1.3 Accessories and Options

Following is a list of additional accessories and options that may be required for your application. Please check with your PULNiX representative before you install your camera to determine what you might need.

- PD-12U series power supply
- 12P-02S power cable
- 26CL-02-26 Camera Link cable

2.2 Camera Setup

2.2.1 Heat Dissipation

The TM-4000CL is a compact 2K by 2K camera. Since all the electronics have been packed in a compact package, the outer case of the camera gets hot due to heat dissipation. For optimal performance, PULNiX recommends using a cooling fan to set up a positive air flow around the camera and following the precautions below.

- Mount the camera on a large heat sink (camera bracket) made out of heat-conductive material like aluminum.
- Make sure the flow of heat from the camera case to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate the free flow of air.

Please contact JAI PULNiX, Inc. at (800) 445-5444 or send an E-mail to imaging@jaipulnix.com if you have any questions.

2.2.2 Connector Pin Configurations

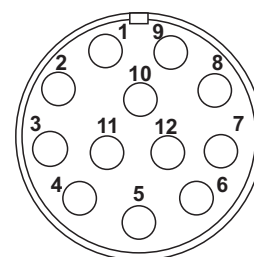
2.2.2 (a) 12-Pin Connector

The TM-4000CL has a 12-pin Hirose connector for power input and signal integration. Pin #1 is Ground and pin #12 is +12V DC. The pin-out table is shown below. Serial communication camera control is done via the Camera Link connector on the rear panel of the camera.

TABLE 1. 12-Pin Connector

Pin	Description	Pin	Description
1	GND	7	NC/VD in *
2	+12V DC	8	Strobe
3	GND (analog)	9	NC/HD in *
4	Video out	10	NC/RXD (RS-232) *
5	GND (digital)	11	NC/Integration Control *
6	NC/VINIT in *	12	NC/TXD (RS-232) *

*. Option



2.2.2 (b) Digital I/O Connector

The TM-4000 has a 26-pin connector on the rear panel to output Camera Link data. The connector pin-out is shown in Table 2 on page 5.

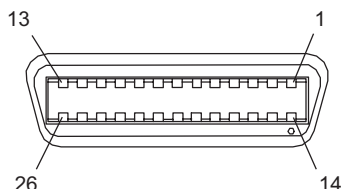


TABLE 2. Connector and Pin-out Configurations

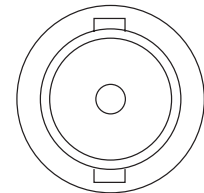
Camera Link Connector					
Pin #	Description	I/O	Pin #	Description	I/O
1	GND		14	GND	
2	Tx OUT 0-	Out	15	Tx OUT 0+	Out

Camera Link Connector (Continued)					
Pin #	Description	I/O	Pin #	Description	I/O
3	Tx OUT 1-	Out	16	Tx OUT 1+	Out
4	Tx OUT 2-	Out	17	Tx OUT 2+	Out
5	Tx CLK OUT -	Out	18	Tx CLK OUT+	Out
6	Tx OUT 3-	Out	19	Tx OUT 3+	Out
7	SerTC+	In	20	SerTC-	In
8	SerTFG-	Out	21	SerTFG+	Out
9	VINIT- /CC1-	In	22	VINIT+	In/CC1+
10	INTEG+/CC2+	In	23	INTEG-	In/CC2-
11	EX-HD-/CC3-	In	24	EX-HD+	In/CC3+
12	EX-VD+/CC4+	In	25	EX-VD-	In/CC4-
13	GND		26	GND	

Note: SerTC: Serial To Camera
SerTFG: Serial to Frame Grabber

2.2.2 (c) Analog Output Connector

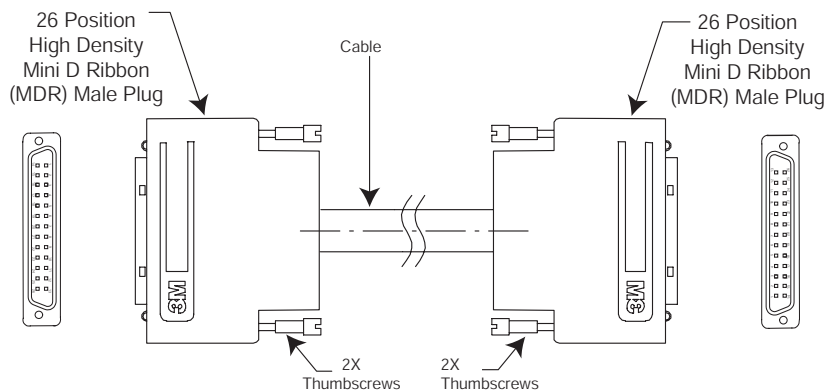
The TM-4000CL has a BNC connector on the rear panel to output analog video signal (Channel “A” only at 40 MHz).



2.2.3 Camera Link Cable

The 26CL-02-26 cable assembly has been standardized as the Camera Link cable. This cable has a 26-pin connector on both ends. This is a straight-through cable and the pin-out configuration is shown in Table 2 on page 5. Contact PULNiX for cable lengths other than 2 meters.

FIGURE 2. 3M Camera Link Cable



Note: For CL versions, serial communication for camera control is done via the Camera Link connector on the rear panel of the camera.

2.2.4 Power Supplies and Power Cable Setup

2.2.4 (a) Power Supplies

The TM-4000CL camera requires 12V DC power that is obtained through the 12-pin connector located on the rear panel of the camera. PULNiX recommends the following power supplies:

PD-12UU	100-240V AC/12V DC	1.2A universal voltage power supply, US Plug
PD-12UUP	PD-12UU with 12-pin connector	US plug
PD-12UE	PD-12UU	European plug
PD-12UEP	PD-12UU with 12-pin connector	European plug

For users providing power through the 12-pin connector, the PD-12P, PD-12UEP and PD-12UUP power supplies are available with the 12-pin mating connector already attached to the leads from the power supply. The PD-12UU and PD-12UE power supplies can be connected to the PULNiX power cable via a terminal strip or directly.

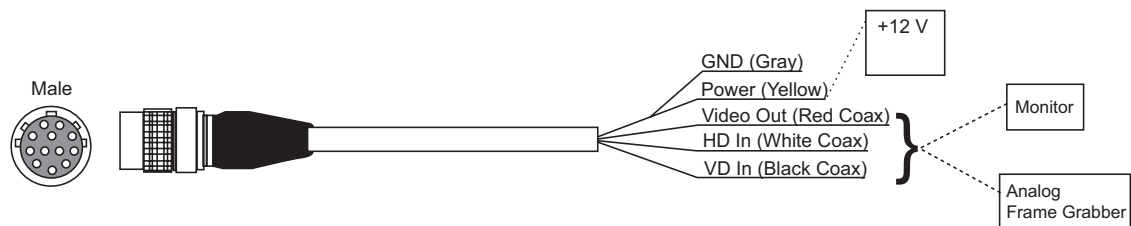
When wiring the PD-12UU and PD-12UE power supplies directly, please note the following:

- The lead ends must be twisted together and tin-soldered for strength and electrical continuity.
- Shrink tubing or a similar insulator should be used to prevent exposed leads from touching and shorting.
- The +12V lead is marked with a red stripe or white lettering; be sure not to reverse the leads.
- All connections must be properly insulated to prevent shorting.

2.2.4 (b) PULNiX Power Cables

If you are using PULNiX power cables such as the 12P-02S, please refer to the 12-pin connector pin-out diagram below. The cable pin-out diagram is shown in Figure 3 below. The color-coded leads use Gray for Ground and Yellow for +12V.

FIGURE 3. 12P-02S Interface Cable (optional)



12P-02S Interface Cable					
Pin#	Lead Color	Function	Pin#	Lead Color	Function
1	Gray	GND	7	Black coax	VD Input*
2	Yellow	+12V DC	8	White coax shield	Strobe out
3	Red coax shield	(analog)	9	White coax	HD Input*
4	Red coax	Video Out	10	Brown	RXD (RS-232)*
5	Orange coax shield	(digital)	11	Blue	Integration*
6	Orange coax	VINIT IN*	12	Black coax shield	TXD (RS-232)*

*. Optional

Note: Make sure that the unused leads are not touching and that there is no possibility that exposed wires could cause the leads to short.

2.2.4 (c) Building Your Own Power Cable

Refer to the 12-pin connector pin-out in Figure 3 on page 8. Connect the Ground lead to pin #1, and the +12V DC lead to pin #2 of the 12-pin connector. Power must be DC-regulated, and of sufficient current to properly power the camera.

2.2.4 (d) Attaching the Power Cable to the Connector

The 12-pin connector is keyed and will only fit in one orientation. Follow these directions to properly attach the power cable to the camera connector:

- 1. Rotate the connector while applying slight pressure until the keyways line up.
- 2. Press the connector into place until firmly seated.
- 3. Plug the power cord into the 100V AC socket. This will power the camera up.

2.2.5 Attaching the Analog Video Output

When connecting the TM-4000CL to an analog frame grabber or a monitor, use the BNC connector on the rear panel of the camera. The input of the monitor should be balanced for 75 ohms termination. Standard RG-59 type coaxial cable should carry a full video signal for up to 500 feet. The TM-4000CL has a two-row binning mode that can be used to display real-time images on PULNiX’s PVM-942 or PVM-1242 monitors. These monitors are specially modified to accept a 30Hz progressive scan image.

The multi-conductor cable 12P-02S from PULNiX can be used to transmit analog video, power, sync. signals, and serial communication. The mini coaxial leads in PULNiX multi-conductor cables are designed for short runs of no longer than 50 feet.

***Note:** Make sure that no extraneous wires are visible which could cause a short.*

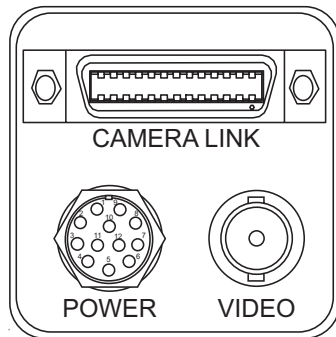
2.2.6 Attaching the Camera Lens

The TM-4000CL camera accepts 1.2" or larger format size C-mount lenses. To attach the C-mount lens¹ to the camera, carefully engage the threads and rotate the lens clockwise until it firmly seats on the mounting ring. Do not force the lens if it does not seat properly. Please note that some lenses with extremely long flangebacks may exceed the mounting depth of the camera.

1. C-mount to F-mount and C-mount to K-mount adapters are available for larger format lenses (35mm). Check with local photography dealers for these lens adapters.

3 Operation

3.1 Camera Rear Panel



3.1.1 Digital I/O Connector (Camera Link)

Refer to Section 2.2.3 on page 6 for information on digital output connectors.

3.1.2 Analog Output Connector

The camera has a BNC connector on the rear panel to output analog video signal.

3.1.3 Power and External Sync Connector

Refer to Section 2.2.2 (b) on page 5 for information on the power and external sync. connectors.

3.2 Progressive Scanning

Standard TV-system scanning is 525 lines interlace scanning as specified in the RS-170 protocol. Every other horizontal line (odd lines and even lines) is scanned at a 60Hz rate per field, and the scanning is completed with two fields (one frame) at 30Hz rate. Because of the interlace scanning, the vertical resolution of CCD cameras is limited at 350 TV lines, regardless of the horizontal resolution. When electronic shutter is applied, the CCD can hold only one field of charge at each exposure. This means that the vertical resolution of the electronic-shutter camera is only 244 TV lines. The situation is the same for an HDTV-format camera, since it has interlaced scanning and the vertical resolution of the shuttered image is 500 lines.

The TM-4000CL uses a state-of-the-art progressive scanning interline transfer CCD which scans all lines sequentially from top to bottom at one frame rate. Like a non-interlace computer screen, it generates a stable, crisp image without alternating lines and provides full vertical TV resolution of 1000 lines (a normal TV monitor display may not be able to show 1000 lines due to monitor resolution of 30Hz scanning).

The interline transfer architecture is also important to generate simultaneous shuttering. This is different from full frame transfer architecture which requires a mechanical shutter or strobe light in order to freeze the object motion.

The TM-4000CL outputs the progressive-scanned image with an electronic shutter in two different formats:

1. Progressive-scanning digital and analog output

The CCD signal goes through A/D and D/A converters and through 10-bit in, 10-bit or 8-bit out look-up table (LUT).

The analog output is the same as 75 ohms, 714mVp-p format available from BNC and 12-pin connector. The digital output is available via the Camera Link connector.

2. Partial Scan Mode

By selection, the camera has centered 1000 lines, 500 lines, and 250 lines. Partial scan mode, 1000 lines, partial scan's frame rate is 28fps. 500 lines is 50 fps, 250 lines is 80 fps.

3.3 Electronic Shutter

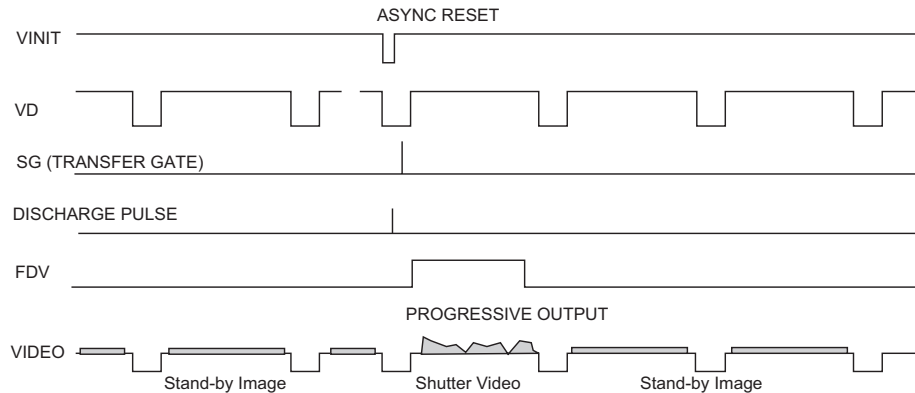
The TM-4000CL has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. A built-in manual shutter speed control selects the electronic shutter rate of 1/60 (non-async mode only), 1/125, 1/250, 1/500, 1/1,000, 1/2,000, 1/4,000, 1/8,000, or 1/16,000 second.

With VINIT high (5V), the CCD keeps discharging. With a negative pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 1000 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

3.4 Integration

The CCD imager of the TM-4000CL can be exposed for longer than the normal scan timing of 1/15 sec. This integration feature provides extra sensitivity for dark-environment applications. The progressive-scan imager permits a full frame of resolution in non-interlace format. Integration is achieved by controlling CC2 Camera Control line through the Camera Link cable to low (GND) or providing pulse-width control up to 1/15 frames. Please refer to Figure 2.2.2 on page 5 for pin-out information on the 12-pin connector.

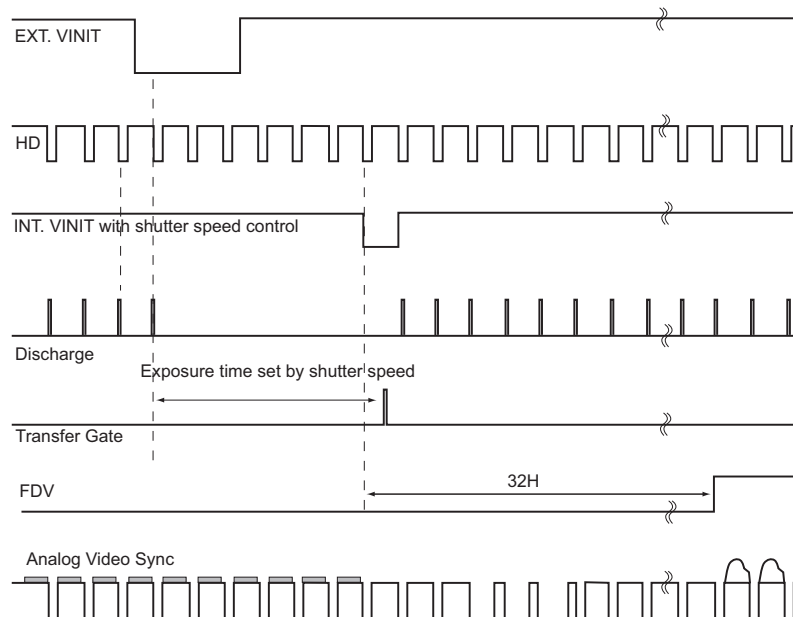
3.5 Asynchronous Reset



The TM-4000CL camera includes two modes to control the asynchronous reset and shutter speed:

- Internal Shutter Speed Control
- External VINIT with Pulse Width

3.5.1 Internal Shutter Speed Control (TM-4000CL)

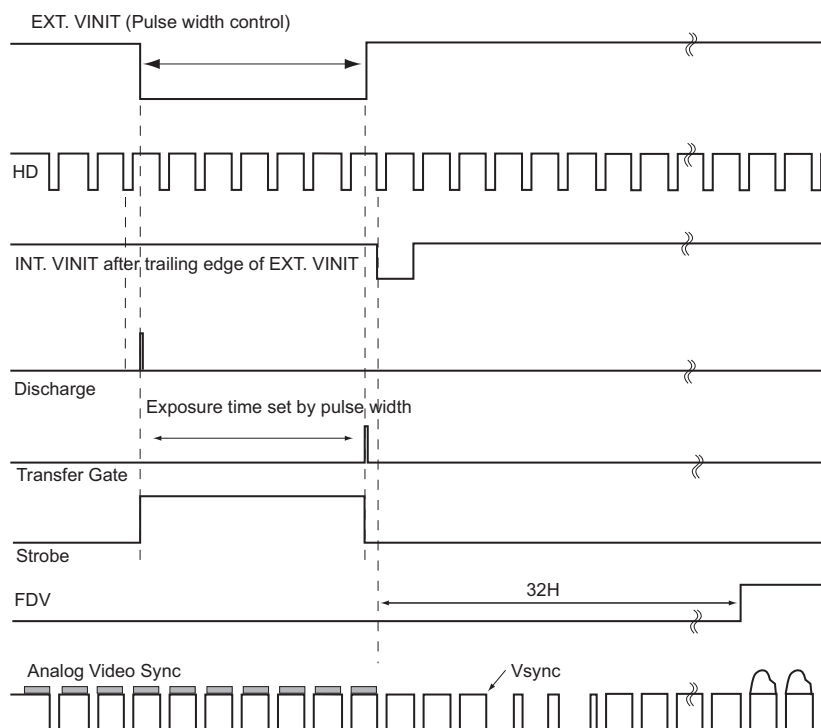


The video signal starts with internal VINIT. The camera operates the reset and shutter in the same way as the external pulse width control mode. When the external VINIT pulse is applied, internal VINIT is latched to HD and the internal VINIT is delayed to set up the shutter speed period. The shutter speed is controlled by communication software from “1” to “8.” Video output timing starts right after the internal VINIT and single shots, FDV is output at the internal VINIT timing.

3.5.2 External VINIT With Pulse Width No-Delay Shutter and ROI (Read-out Inhibit) (TM-4000CL)

For multiple-camera applications such as 2D or 3D measurement and multi-angle inspection, simultaneous image capturing at an exact shutter timing for all cameras is a critical requirement. The TM-4000CL's asynchronous pulse-width control mode provides no-delay shutter as standard. Regardless of the internal pulse timing, the camera discharges at the VINIT leading edge and transfers charges at the trailing edge of the pulse. Even though each camera runs with slightly different H and data clock timing, the image capturing is exactly simultaneous.

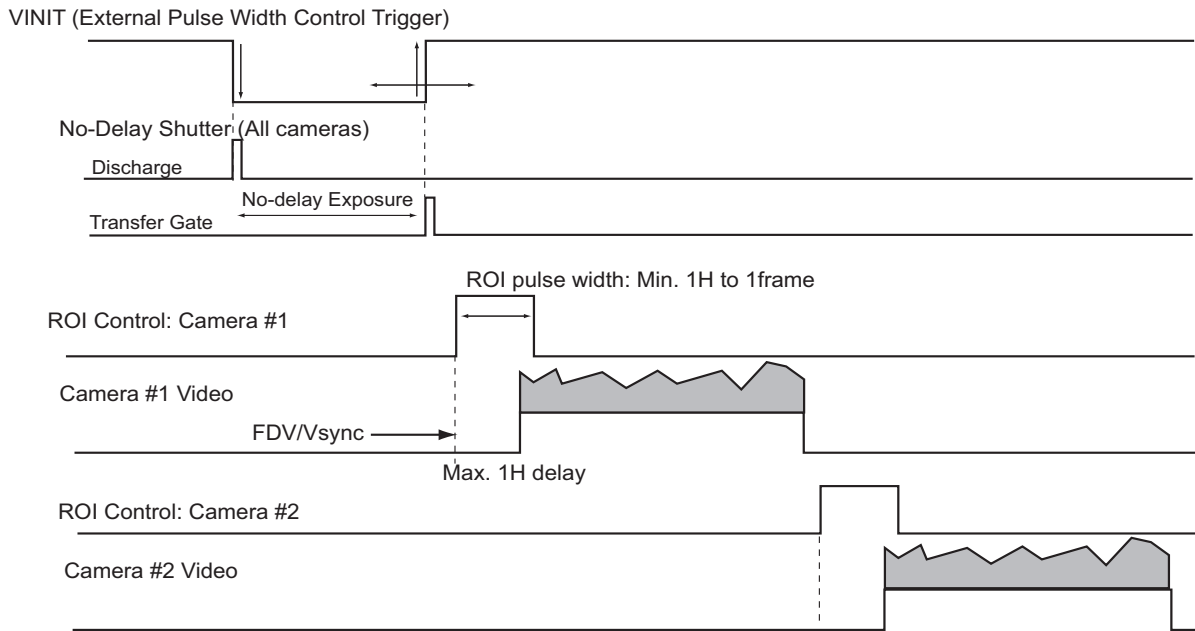
FIGURE 4. No-Delay Shutter



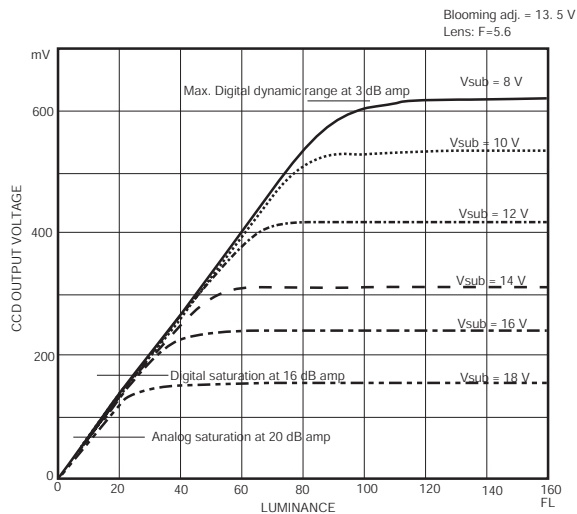
The TM-4000CL camera also has read-out-inhibit control (ROI) to control the vertical clock start (Async Shutter #9). When ROI is low, V-clock is stopped and the transferred charges remain in the vertical shift registers, which work like CCD memory. When the ROI is high, it clocks out the CCD data. This helps a single frame grabber process multiple images in pipeline processing (sequential process).

Note: When the ROI function is not used, make sure that the INTEG/ROI CCL input is kept logic high during Async. pulse width control mode.

FIGURE 5. No-Delay Shutter and Read-Out Inhibit



3.6 Dynamic Range Control



The typical interline transfer CCD has fixed noise levels based on dark current (thermal or KT noise), pattern noise, and the operating clock speed. In general, the level of the 20 MHz pixel clock CCD at room temperature is around 20 to 50 electrons. The maximum capacity of CCD charges is limited by the well capacity at saturation. The range is limited by the structure and the pixel size.

The TM-4000CL uses a CCD with $7.4 \mu\text{m} \times 7.4 \mu\text{m}$ pixel and two-phase vertical shift register structure. The well capacity is 40,000 electrons. The theoretical dynamic range is $40,000:30 = 1333:1$ (60 dB).

A typical CCD camera does not use the full dynamic range due to the nominal gain and the output specification such as RS-170. The typical CCD camera's gain is set at 16 to 22 dB and the RS-170 video level is 714 mV. Using 20 dB gain for the calculation, CCD output is limited to $714/10 = 71.4$ mV. Since the CCD's saturation voltage is 400 mV to 500 mV, it uses less than 1/5 of the full dynamic range.

Machine vision and outdoor applications, cannot afford to miss image information behind the saturation, which is why the dynamic range adaptation is critical.

3.6.1 Programmable Look-Up Table (LUT) and Knee Control

The TM-4000CL has a built-in LUT (look-up table) for dynamic range control.

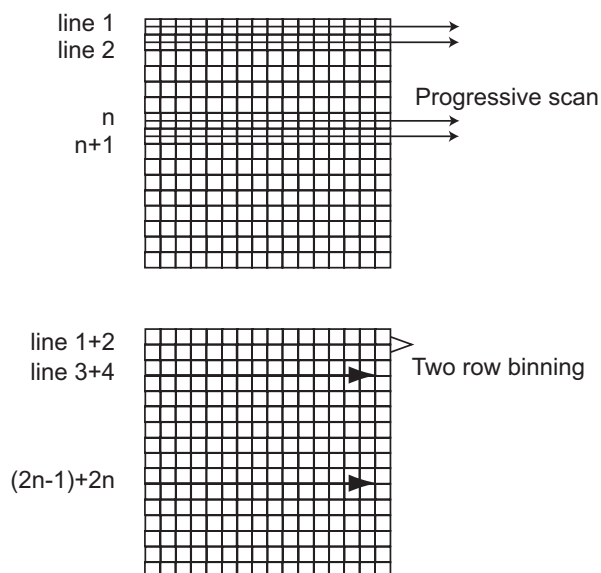
At a specific gain setting, the offset (minimum level.... dark point) and A/D reference top voltage (maximum level... saturation point) are set to 10-bit A/D input so that the full dynamic range of the CCD is utilized at 10-bit references as the input and the LUT output is converted into 8-bit to adjust the gamma correction.

The look-up table has two knee points (variable gamma selection) that allow the 10-bit input to be segmented into three regions. The look-up table selection can be made by knee curve direct input.

3.7 Scan Modes

The TM-4000CL supports the following scan modes:

FIGURE 6. Scan Modes



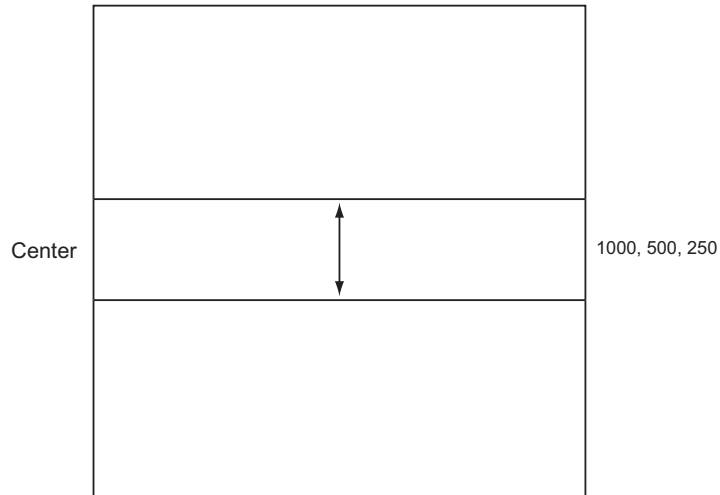
3.7.1 Full Progressive Scan

Normal scanning mode the TM-4000CL is for 2048 x 2048 pixels. The standard speed with dual-channel output is 15 frame/sec at the pixel clock of 40 MHz. The progressive scan reads every line from

top to bottom and, unique in an interlace-scan camera, all lines are obtained per image capturing with electronic shutter.

3.7.2 Partial Scan

TM-4000CL has centered 1000 lines, 500 lines and 250 lines partial scan mode.



3.8 External Sync and Pixel Locking

The TM-4000CL accepts an external sync of standard HD and VD at TTL level for general locking to a system sync and clock. The frequency requirement is as follows:

Full Progressive Scan:

$$f_{HD} = 30.769 \text{ KHz} \pm 2\%$$

$$f_{VD} = 14.79 \text{ Hz} \pm 2\%$$

(Internal Master clock = 80.00 MHz,

Pixel clock = 40.00 MHz)

100L Partial Scan:

$$f_{HD} = 30.769 \text{ KHz} \pm 2\%$$

$$f_{VD} = 27.97 \text{ Hz} \pm 2\%$$

500L Partial Scan:

$$f_{HD} = 30.769 \text{ KHz} \pm 2\%$$

$$f_{VD} = 49.63 \text{ Hz} \pm 2\%$$

250L Partial Scan:

$$f_{HD} = 30.769 \text{ KHz} \pm 2\%$$

$$f_{VD} = 79.92 \text{ Hz} \pm 2\%$$

Note: The external sync is not available in two-row binning.

3.9 Camera Timing Charts

Model: TM-4000

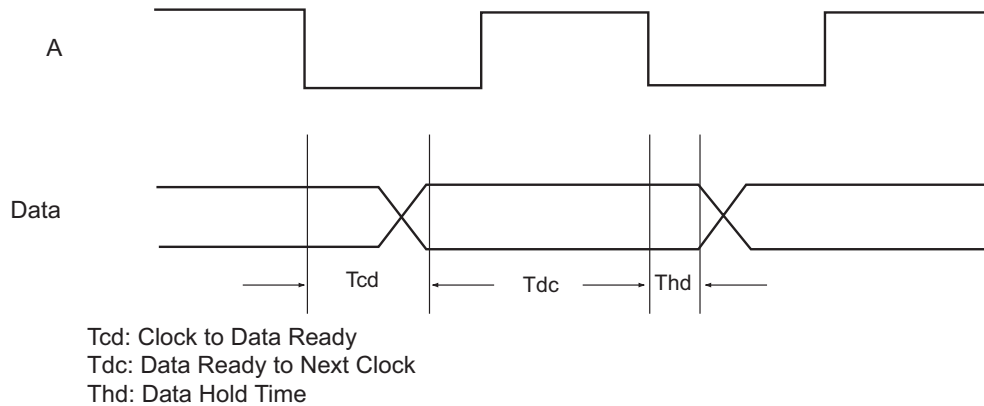
Operation Mode: Dual Tap Output

Master Clock: 80.000 MHz, M=12.5 nsec

Pixel Clock: 40.000 MHz, P= 25.0 nsec

1. Pixel Clock and Digital Data

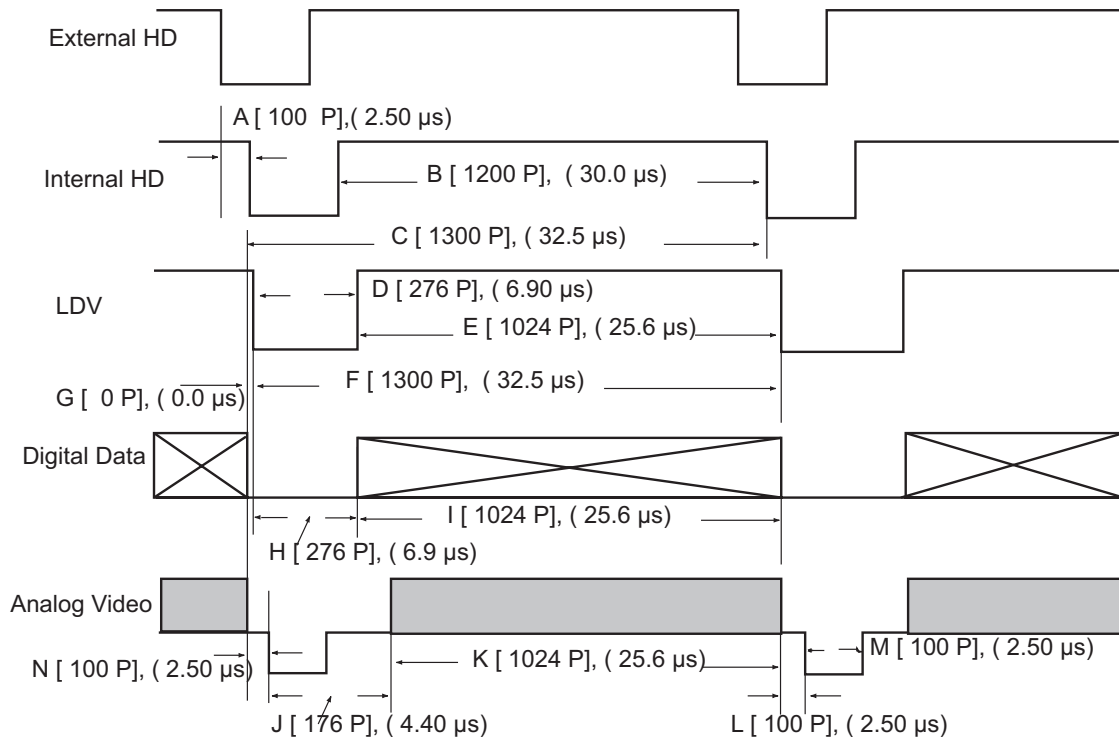
Pixel Clock



Tcd = 12.5 nsec, Tdc = 12.5 nsec, Thd = 7 nsec.

2. Horizontal Signals Timing

fHD = [30.78 KHz]
tHD = [32.5 μ sec]



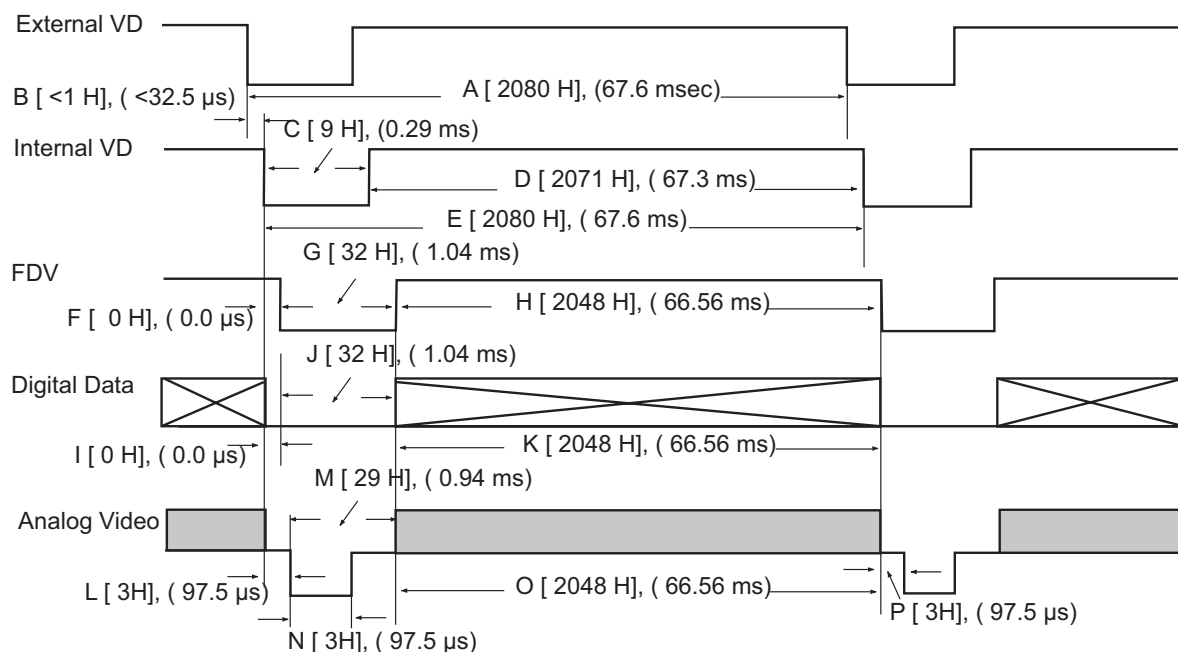
Model: TM-4000

Operation Mode: Dual Tap Output
Full Scan
14.79 Frames/second

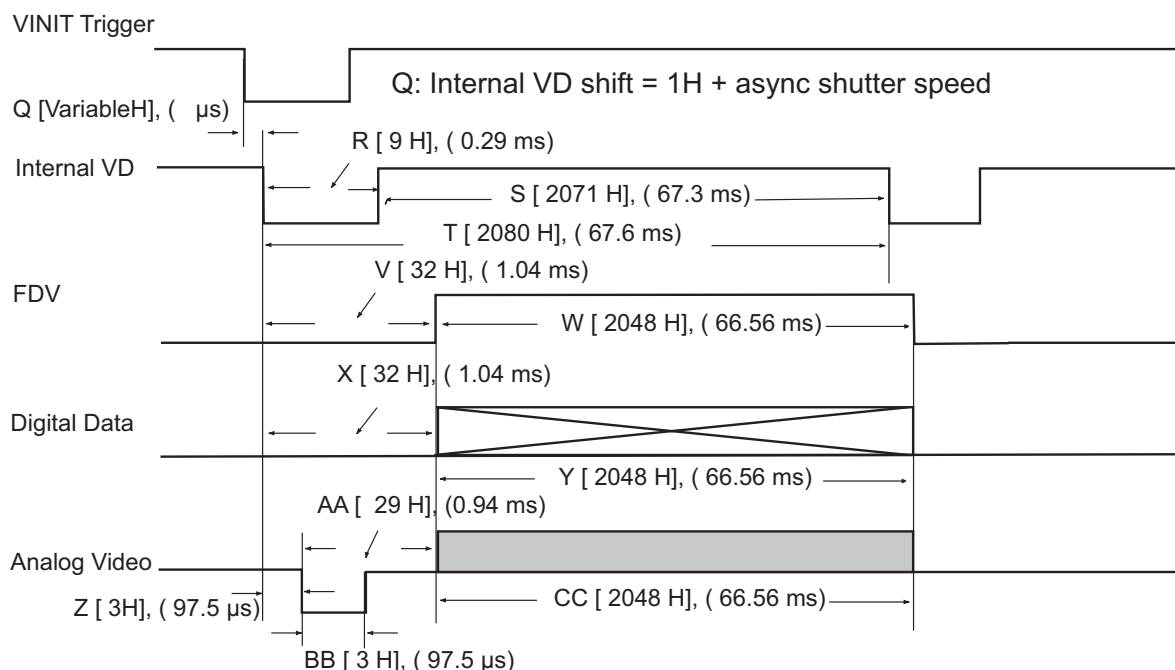
Master Clock: 80.000 MHz, M= 12.5 nsec

Pixel Clock: 40.000 MHz, P= 25.0 nsec

3. External Reset Timing and Vertical Signals Timing



4. Async Reset Timing

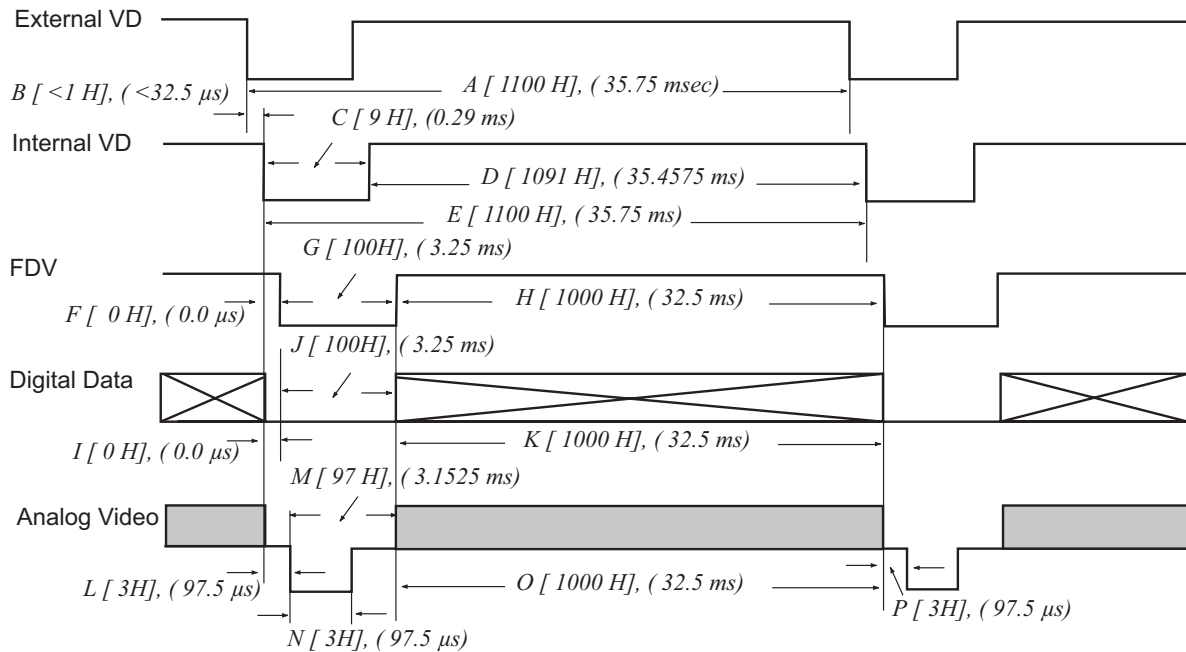


Model: TM-4000

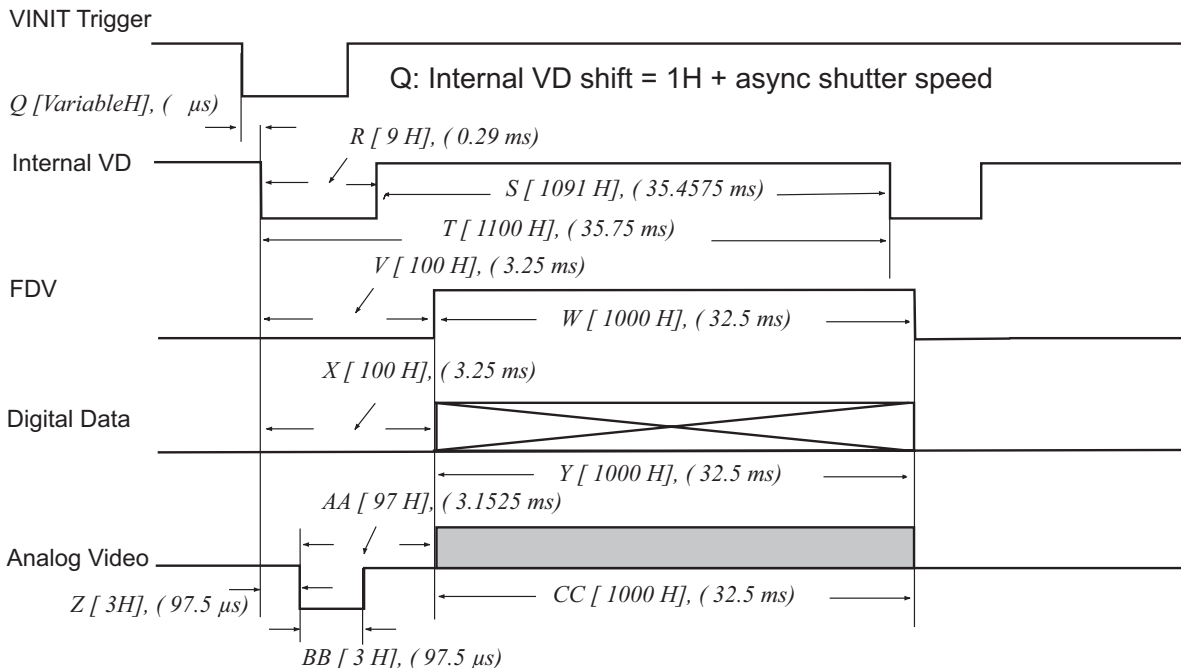
Operation Mode: Dual Tap Output
Centered 1000Ls PS
27.97 Frames/second

Master Clock: 80.000 MHz, M= 12.5 nsec
Pixel Clock: 40.000 MHz, P= 25.0 nsec

5. External Reset Timing and Vertical Signals Timing



6. Async Reset Timing



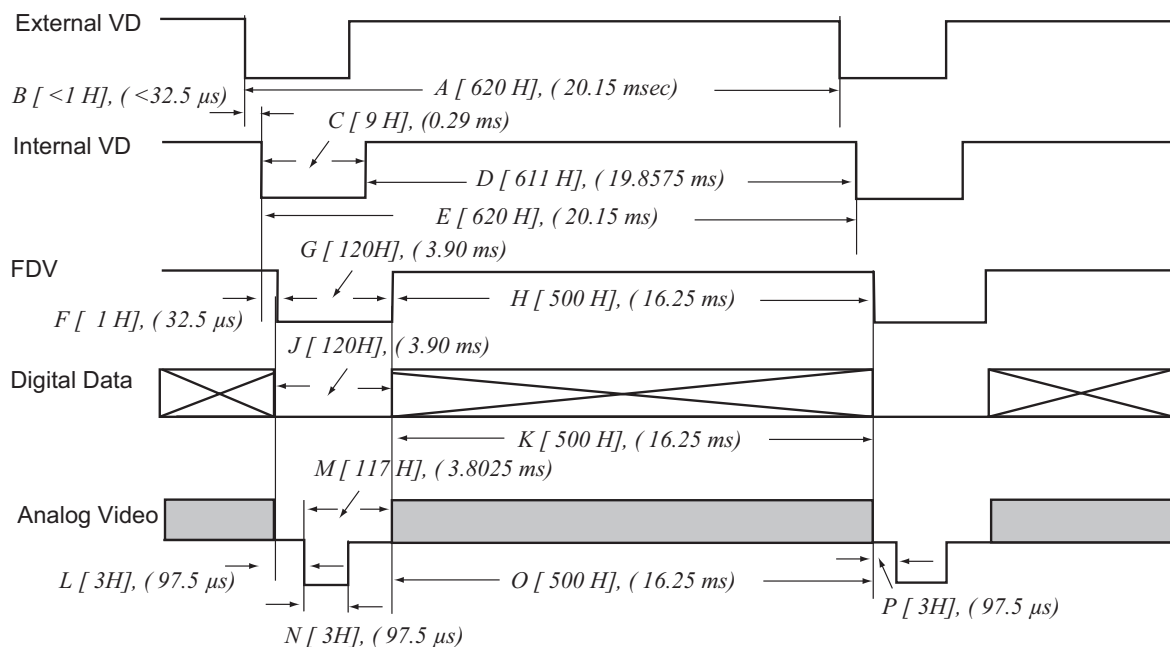
Model: TM-4000

Operation Mode: Dual-Tap Output
Centered 500Ls PS
49.63 Frames/second

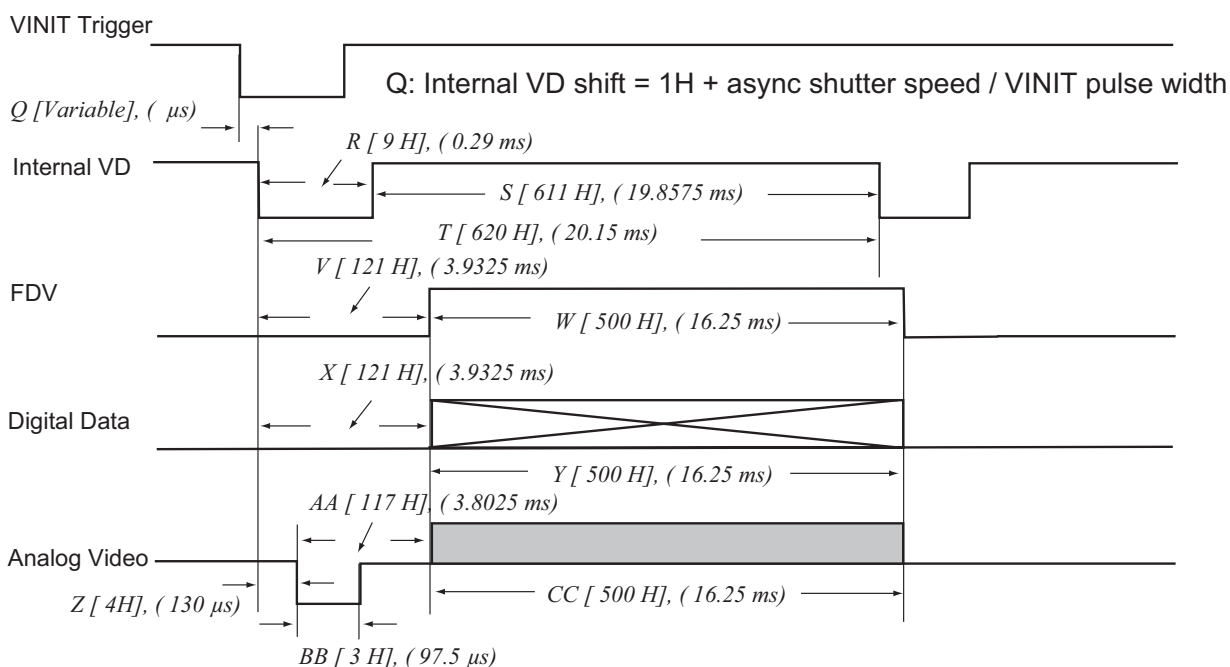
Master Clock: 80.000 MHz, M= 12.5 nsec

Pixel Clock: 40.000 MHz, P= 25.0 nsec

7. External Reset Timing and Vertical Signals Timing



8. Async Reset Timing

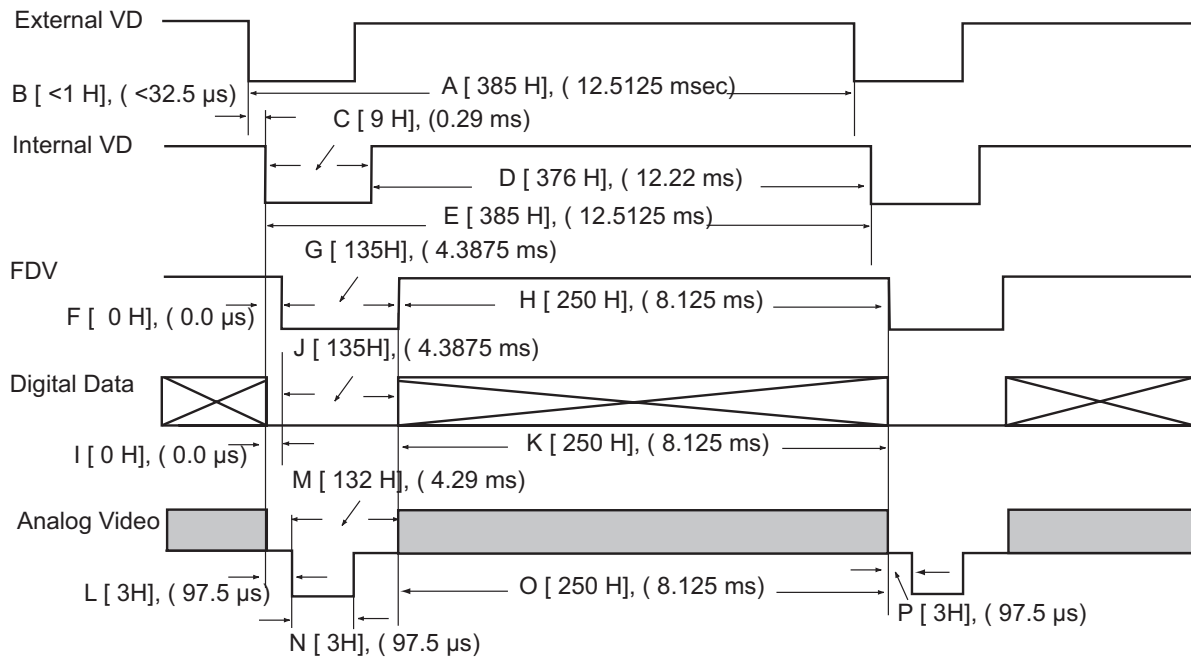


Model: TM-4000

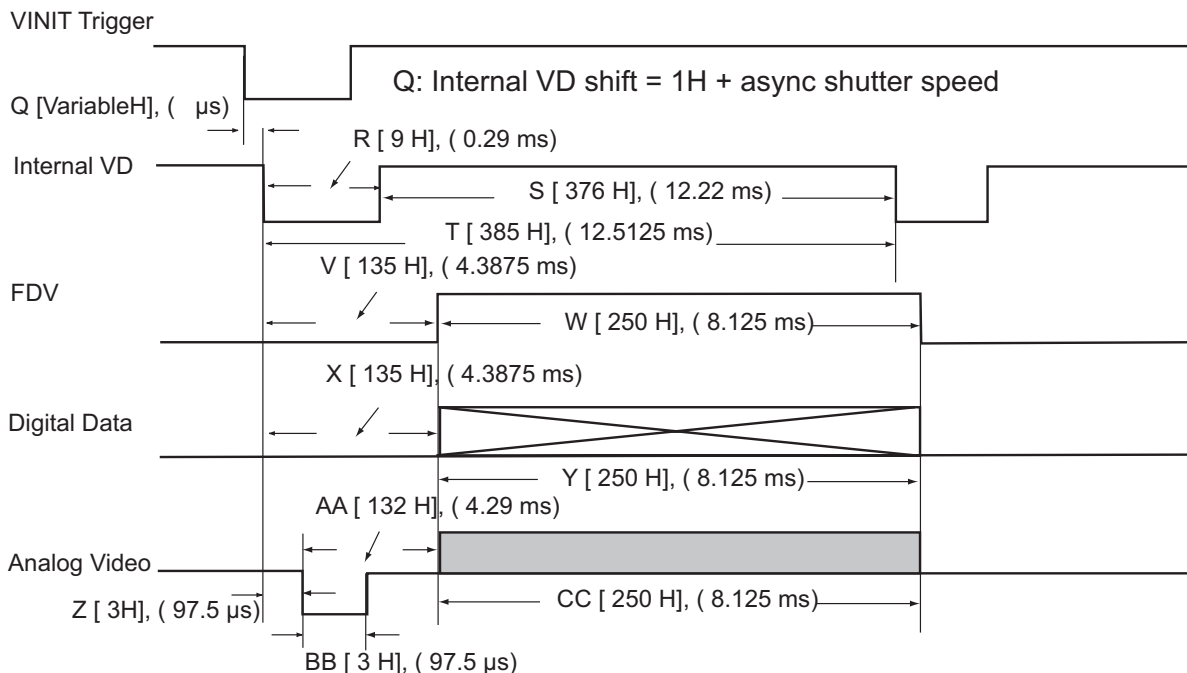
Operation Mode: Dual Tap Output
Centered 250Ls PS
79.92 Frames/second

Master Clock: 80.000 MHz, M= 12.5 nsec
Pixel Clock: 40.000 MHz, P= 25.0 nsec

9. External Reset Timing and Vertical Signals Timing



10. Async Reset Timing



3.9.1 Video Output Diagram

Model: TM-4000

Operation Mode: Dual-Tap Output

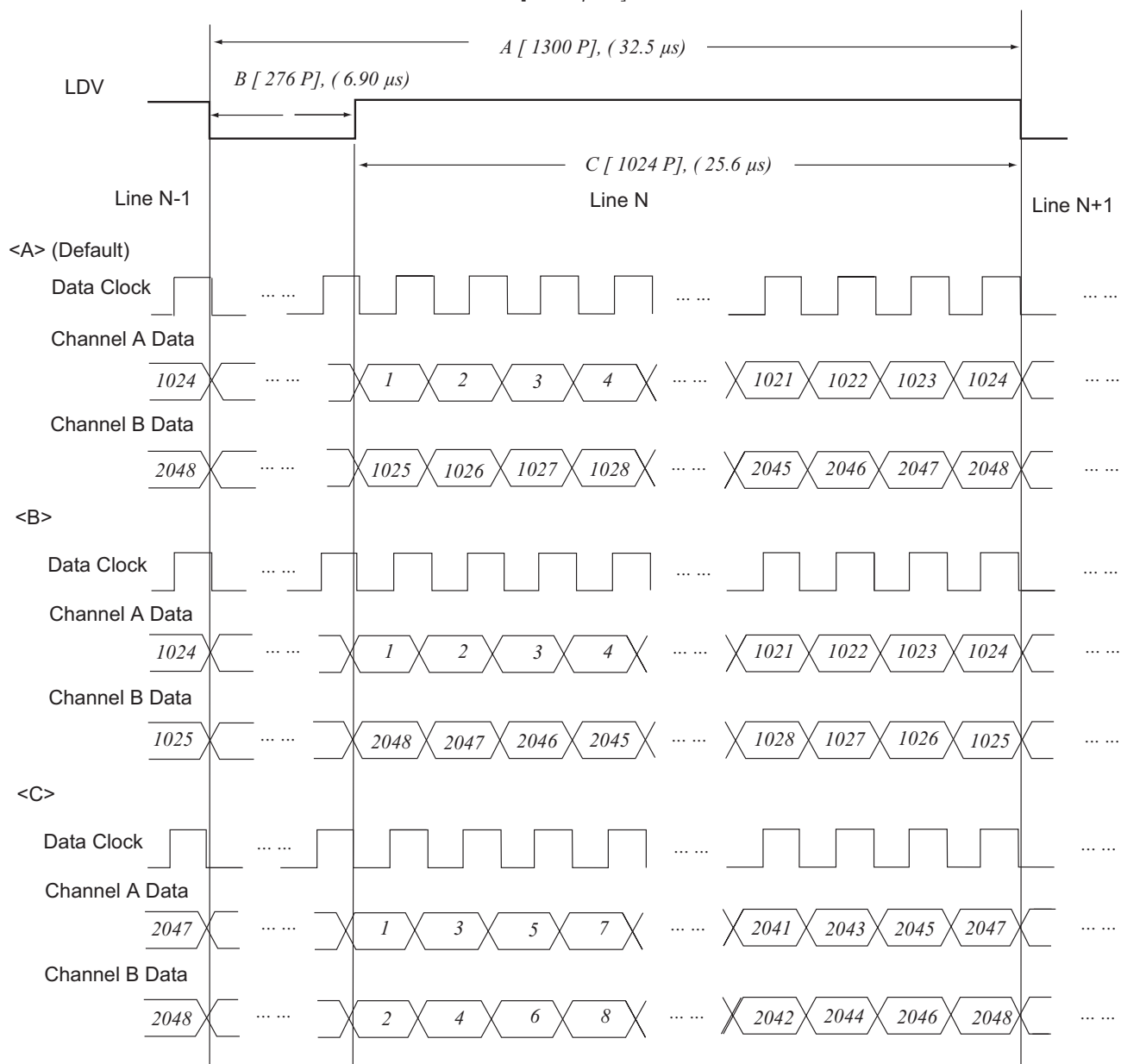
Master Clock: 80.000 MHz, M=12.5 nsec

Pixel Clock: 40.000 MHz, P= 25.0 nsec

1. Horizontal Timing

$f_{HD} = [30.78 \text{ KHz}]$

$t_{HD} = [32.5 \mu\text{sec}]$



3.10 Serial Communication Kit

The Camera Link version's control software is included in the AccuPiXEL Camera Control software.

4 TM-4000CL Preliminary Command List

The LVDS-version camera can be controlled via RS-232 commands. The Start character is always “:” and the End character is always “CR” (return). For example, to set Asynchronous Pulse Width Mode, send the command :SA9“CR” to the camera. The following table contains RS-232 commands that can be used to control the camera.

TABLE 3. TM-4000CL Preliminary Command List

Command Parameters	End of Command	Ack Response	Description
Camera Control			
:VRA=	DDD	<cr>	:0<cr> Set reference voltage for ch A (DDD = 9 bit in hex <1 sign bit + 8 data bits>)
:VRB=	DDD	<cr>	:0<cr> Set reference voltage for ch B (DDD = 9 bit in hex <1 sign bit + 8 data bits>)
:MGA=	DDD	<cr>	:0<cr> Set CDS gain for ch A (DDD = 000 - 2FF)
:MGB=	DDD	<cr>	:0<cr> Set CDS gain for ch B (DDD = 000 - 2FF)
:VRA?		<cr>	:0VA[DDD]<cr> Enquire reference voltage for ch A
:VRB?		<cr>	:0VB[DDD]<cr> Enquire reference voltage for ch B
:MGA?		<cr>	:0GA[DDD]<cr> Enquire CDS gain for ch A
:MGB?		<cr>	:0GB[DDD]<cr> Enquire CDS gain for ch B
Test Pattern & Auto Balancing			
:TPTN	N	<cr>	:0<cr> Enable/Disable Test Pattern (N=1 Enable, N=0 Disable)
:EABL		<cr>	:0<cr> Enable auto gain balance
:DABL		<cr>	:0<cr> Disable auto gain balance
:ABL?		<cr>	:0AB[N]<cr> Check if auto gain balance is enable (N=1 Enable, N=0 Disable)
:EACL		<cr>	:0 <cr> Enable auto black level balance
:DACL		<cr>	:0 <cr> Disable auto black level balance
:ACL?		<cr>	:0AB[N]<cr> Check if auto black level balance is enabled (N=1 Enable, N=0, Disable)
Shutter Control			
:MSH=	S	<cr>	:o<cr> Set Manual Shutter (S= 0 - 9)
:DSH=	DDD	<cr>	:o<cr> Set Direct Shutter (DDD=000 - 81F)
:ASH=	S	<cr>	:o<cr> Set Async Shutter (S= 0 - 9)

TM-4000CL Preliminary Command List

Command Parameters	End of Command	Ack Response	Description
:SHR?		<cr>	:o[shtr]<cr> Enquire current shutter mode and number
Lookup Table			
:GM45		<cr>	:o<cr> Set gamma (.45) table
:LINR		<cr>	:o<cr> Set linear table
:KNEE=	X1Y1X2Y2	<cr>	:o<cr> "Set knees (X1,Y1,X2,Y2 = 00 - FF)"
:SLUT	N	<cr>	:o<cr> Set positive knee or negative knee (0=positive, 1=negative)
:LUT?		<cr>	:o[lut]<cr> Enquire current LUT setting
Memory Pages			
:WRPG	N	<cr>	:o<cr> Write Page N (N = 0 - 6; Page 0 is factory setting and not allowed to change by customer)
:LDPG	N	<cr>	:o<cr> Load Page N (N = 0 - 6)
:RDPG	N	<cr>	:o[settings]<cr> Read (Report) Page N (N = 0 - 6)
:RPST		<cr>	:o[settings]<cr> Report Current Overall Settings
Scan Mode			
:SMD	M	<cr>	:o<cr> "Set Mode (M = A,B,C,D)"
:SMD?		<cr>	:oMD[mode]<cr> Enquire current scan mode
Miscellaneous			
:CAM?		<cr>	[CamMode] Enquire Camera Model
:VER?		<cr>	[version] Enquire current version of firmware

Note: If a command is not accepted for any reason, the camera will return a Nack response ""e""<cr>.

5 Troubleshooting

5.1 Problems and Solutions

Following are troubleshooting tips for common problems. In general, problems can easily be solved by following these instructions. If the following remedies fail to offer a solution to your problems, please contact a PULNiX representative.

5.1.1 Symptom: No Video

Remedies: Check that the following are properly connected and operational.

- Power supplies
- Power cables
- Main power source
- Shutter control
- Async mode
- Lens
- Digital output cable
- Analog video cable

5.1.2 Symptom: Dark Video

Remedies: Check that the following are properly connected and operational.

- Shutter selection
- Iris opening on the lens

5.1.3 Symptom: Non-synchronized Video

Remedies: Check that the following are properly connected and operational.

- Proper mode output
- Frame grabber software camera selection

5.2 Information and Support Resources

For further information and support:

Phone:	(408) 747-0300 (800) 445-5444
Fax:	(408) 747-0660
E-mail:	imaging@jaipulnix.com
Mail:	JAI PULNiX, Inc. Sales Department 1330 Orleans Drive Sunnyvale, CA 94089 ATTN: Video Applications
Web Site:	www.pulnix.com

6 Appendix

6.1 Specifications

TABLE 4. TM-4000CL Camera Specifications Table

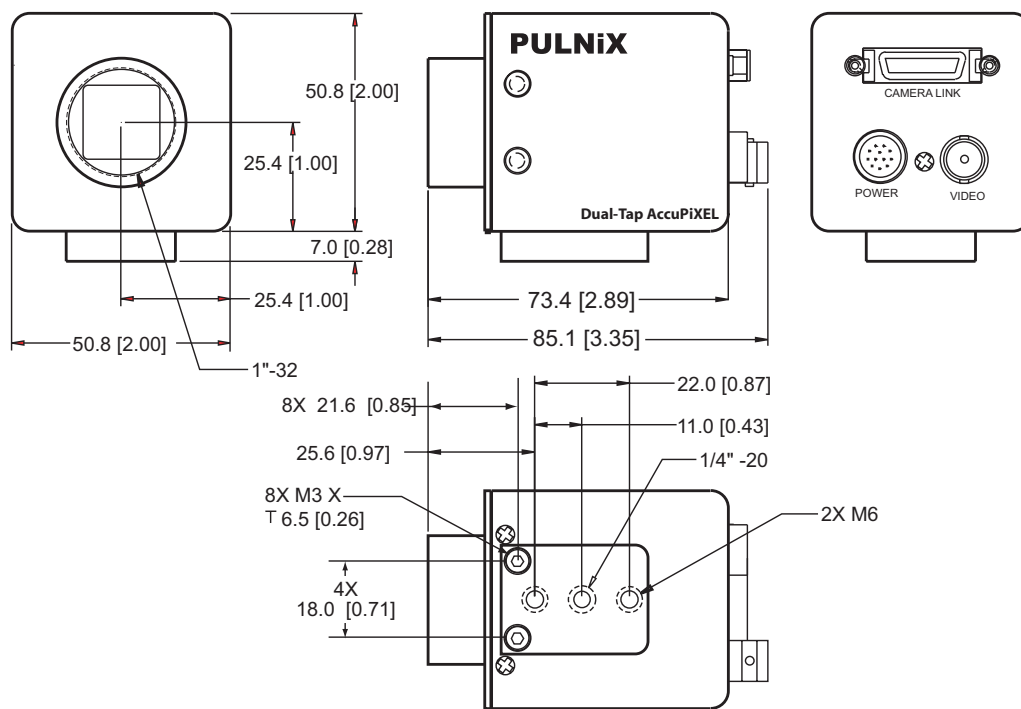
Feature	TM-4000CL
Imager	16.67mm x 16.05mm progressive scan interline transfer CCD
Pixels	2048 (H) x 2048 (V)
Cell size	7.4μm x 7.4μm
Scanning	Full image (2048L) Partial scan 1000 lines, 500 lines and 250 lines
Sync	HD (CC3), /VD, (CC4) RS-644 through Camera Link cable * Full scan mode: VD=14.79Hz±5% HD=30.78kHz±5%
Data clock output	40.000 MHz
Resolution	Digital: 2048 (H) x 2048 (V), (Analog: over 1000 TV lines (H) x 800 TV lines (V))
S/N ratio	48dB min. (AGC: off)
Min. illumination	1.0 lux with factory defaults: f=1.4 without IR cut filter (no shutter) Sensitivity: 16μV/ e-
Video output	Analog: 714 mVp-p composite video, 75 ohms, channel "A" only
AGC	OFF
Gamma	Programmable LUT (1.0 std.)
Lens mount	C-mount (use 1" format lenses or larger)
Power requirement	12V DC, 450mA (current measured at 25°)
Operating temp.	-10°C to 45°C†
Random vibration	7 Grms (10Hz to 2000Hz)
Shock	70G
Size (W x H x L)	50.8mm x 50.8mm x 85.1mm
Weight	155 grams
Optional Accessories	
Power Cable	12P-02S
Power Supply	PD-12UUP (includes power connector)
I/O	26CL-02-26 Camera Link I/O cable

*. Optional Hd, Vd on the 12-pin connector.

†. Refer to Section 2.2.1 on page 4 for information on camera heat dissipation. Image quality will degrade with increasing temperature.

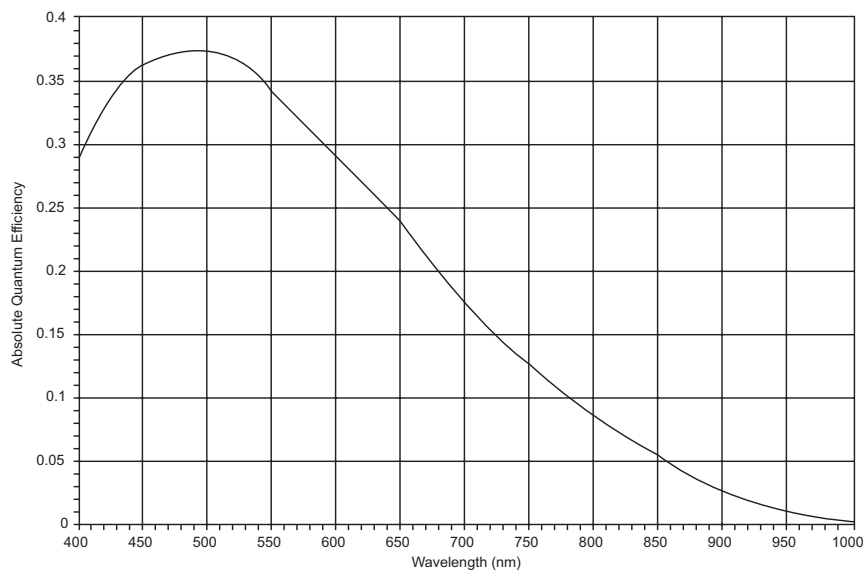
6.1.1 TM-4000CL Physical Dimensions

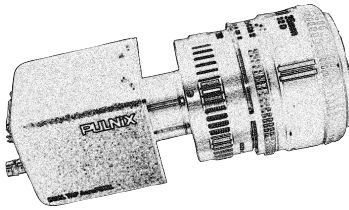
FIGURE 7. Physical Dimensions



6.1.2 Spectral Response

FIGURE 8. Spectral Response





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